March 1948

IMPROVING CROP PLANTS BY INTRODUCTIONS

Drawing Upon the Whole World as Its Nursery, the Bureau of Plant Industry, Soils, and Agricultural Engineering Has Developed Improved Food and Fiber Plants by Exploration and Research, to the Benefit of Both Hemispheres

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"To meet urgent human needs abroad, nearly 18½ million long tons of grain and other food were exported by the United States in the year ending June 30, 1947. * * * Our country was blessed last year with the most bountiful harvest in our history. Our farmers worked hard to produce record crops. * * * Within our ability to share our resources, we will continue to do our part to relieve human suffering and to help other countries to help themselves. It is the course we must follow. * * *"

This significant statement of American agricultural achievement and good will to all mankind was made by the President of the United States on July 3, 1947, in releasing the World Food Program report of the Cabinet Committee. Behind it lies one of the most interesting contributions of agricultural science.

Modern technology as exemplified by the American farmer must receive its just due for record production, not only for last year but for every year since 1940. The real value of the production, however, lies not alone in its total bulk but even more in the diversity of the crops produced. During the war years this country reached a high peak of self-sufficiency because American agriculture in its three centuries of development has drawn upon the whole world as its nursery. Only a few major crops, such as corn and tobacco, are native to the New World, and none to this country. By far the greater bulk of production is represented by crops first grown and cultivated by older civilizations.

It is no more than fitting then that we should now be shipping back to the hungry people of Europe and Asia the wheat and flour to which they have long been accustomed, or that we should be sending rice—half a million tons—to its native China and India.

INTRODUCTIONS OF OLD WORLD CROP PLANTS

The early introduction of Old World crops was a natural consequence of colonization. The colonists and later immigrants brought with them their favorite homeland crops to plant in the New World. Some of these early plantings flourished; others did not prove to be suited to the climate and soils where the colonists settled, and so were unsuccessful. Some, such as rice on the broad savannas of lower Georgia, flourished for a time and then vanished with the development of other new areas of the country more suitable for their production.

Early in the nineteenth century the fledgling Federal Government took note of the need for plant introduction. Circular letters of the Treasury Department in 1819 and 1827 directed consuls "to collect and transmit seeds and plants, with information regarding climate, soil, propagation, cultivation, insect pests, and uses, and agricultural literature." The Secretary of the Navy also requested that naval officers assist in this work. In 1838 an unsuccessful effort was made to establish by congressional action an "agricultural depository in the Patent Office." Commissioner Ellsworth of that Office in 1835 began plant explorations and importations leading to the placement of new plant materials in "every part of the Union."

In these actions are seen the beginnings of what are now the functions of the Division of Plant Exploration and Introduction, of the Bureau of Plant Industry, Soils, and Agricultural Engineering. From these beginnings, too, developed what is now the United States Department of Agriculture.

The real value of a constant source of new and old plant materials became more apparent soon after the turn of the present century. Plant breeding was given new impetus at this time with the rediscovery of the Mendelian principles. Before this, plant importations were made mostly from the standpoint of cultural adaptability. Would the crop grow in this country? Would there be a market for the product?

As plant breeding stepped over into the field of hybridization—seeking the right parentage for improved progeny resistant to the hazards of weather, diseases, and insects—the movement became the genesis of a new role for plant introduction—a tool in the exacting science of genetics. A new phrase—superior germ plasm—crept into the terminology of the plant breeder. After recognizing its existence, the scientist turned his attention to searching out its sources. He was not long in discovering that an abundance of breeding material was a first requisite and that parent stocks from primitive sources were most promising. This was because plants in their native habitat may have withstood natural hazards for thousands of years and thus built up a natural immunity or resistance, which with modern techniques in breeding may be transmitted to improved strains lacking these characteristics.

SOYBEANS

Many of these immigrant crops have surpassed even the fondest hopes of the early pioneers in plant introduction. One of the outstanding examples is the soybean. Scarcely known in this country 50 years ago, the farm value of the seed crop alone in 1946 was more than half a billion dollars, and another 22 percent of the crop was used for hay, pasture, and soil improvement.

The Department made its first introduction of soybeans back in 1898. Before this time there were only eight known varieties grown in this country, and these were confined to limited areas in a few States. By 1907 the Department began to see the value of this widely used bean from the Orient, and the Division of Plant Exploration and Introduction began a vigorous program of obtaining more varieties through consuls, missionaries, seedsmen, and foreign plant explorers. Since 1898 the Department has made about 10,000 introductions from China,

Manchuria, Korea, Japan, Java, Sumatra, Siberia, and India, and from Europen countries into which the plant had also been introduced.

Nearly half these importations resulted from one expedition by two Department plant explorers between 1929 and 1931. Selections were made of varieties to be used for forage purposes, for seed production, and for edible types. These introductions and subsequent breeding for type gave great impetus to soybean production. From plantings of 1,782,000 acres in 1924, the acreage had more than tripled by 1937, when 6,000,000 acres went into soybean production. With the coming of World War II the soybean stepped into a vital role. It was the best source of vegetable oil, a critical item that took first priority in wartime crop-production goals. Under support prices, farmers upped their acreage until in 1946 well over 12,000,000 acres were in soybean production.

Using these introductions as breeding materials has made possible marked improvements through selection and hybridization by the Department and cooperating State agricultural experiment stations. Average yields have been increased from 12.9 bushels per acre for the 1923–32 period to 18.7 bushels for that of 1942–46. The oil content of the crop has been increased from 15 to 20 percent and better. Without the large collection of parent material, plant breeders would have been handicapped in their magnificent accomplishment. More than 90 percent of the soybeans now grown trace their parentage to importations made by the Department.

The story of the soybean and its development did not end with World War II. As a commercial crop it continues to be one of the most versatile products from the American farm. A partial list of its many uses includes products used as livestock feeds, flour, human foods, edible and industrial oils, shortening, margarine, paints, varnishes, adhesives, soaps, plastics, vegetable fiber, printing inks, lecithin, and synthetic rubber.

At present more than 150 mills are engaged in processing the soybean for oil meal alone, representing an investment of more than three-quarters of a billion dollars. Many other firms are engaged in manufacturing numerous food items and industrial products.

Since 1898 the Department has spent about $8,000,000 in the work of plant exploration and introduction. The value received from the soybean alone has repaid this expense many times over.

ALFALFA

Alfalfa, like the soybean, is not a native of America. One of the oldest of cultivated forage crops, alfalfa (meaning "best fodder" in Arabic) apparently originated in southwestern Asia. It was brought to this country about 1850. On the Atlantic coast it was called lucerne. But it was from the West and from the North that alfalfa gained its greatest production impetus.

The first introductions to the western part of the new hemisphere were made by the early Spanish conquerors, Cortez and Pizarro. But it was not until the gold-rush days in California that alfalfa became firmly established. Prospectors taking the water route around the Horn picked up seed of the plant in Chile. Ideally suited to the valleys of California, the crop spread eastward rapidly.

At about this same time a German immigrant, Wendelin Grimm, brought with him to Carver County, Minn., 15 to 30 pounds of alfalfa from his home in the Grand Duchy of Baden and made his first planting in 1858. This proved to be the origin of Grimm alfalfa, the first variety in this country that had sufficient winter hardiness to withstand the cold of the northern tier of States. This advent greatly increased the acreage importance of the crop.

As a hardy perennial that would give several cuttings of hay each season, alfalfa by the late 1920's was growing on about 12,000,000 acres of our farm land. But crowding into compact communities leads to peculiar problems with plants as with man. Where once good alfalfa was consistent over a long period of years, the same fields began to decline and die out after 2, 3, or 4 years. In 1925, Department scientists traced down and identified the decline disease as bacterial wilt caused by the organism *Corynebacterium insidiosum.* Severest damage resulted in the river valleys of Nebraska and Kansas, but the disease had spread also throughout the North Central States.

Plant scientists working on the wilt problem concluded at an early date that the disease could not be controlled by cultural practices. The apparent solution of the problem was breeding for resistance. An evaluation of known varieties in this country was largely negative. It would be necessary to search elsewhere for parent material that would give the required resistance.

In 1929 Department plant explorers penetrated the remote areas of Turkistan, western China, northern India, and northeastern Iran, where alfalfa had been growing for thousands of years and thus had had opportunity to build up natural resistance. Several strains that possessed wilt resistance, including some wild types, were brought back. Then it became the task of the plant breeders to incorporate the desirable qualities of commercial alfalfas, such as Grimm and Common, with the bacterial wilt resistance found in the Turkistan alfalfa.

After years of painstaking crossing and selection, the new variety Ranger, which combines good forage qualities with cold and wilt resistance, is now recognized as an outstanding result of plant exploration and breeding.

Nor was this the only benefit of alfalfa introduction. Another strain collected during the 1929 exploration proved to be resistant to the stem nematode. This minute pest seriously infests the soils in some of the western irrigated valleys. From this strain was developed a variety known as Nemastan, which will make alfalfa production again profitable in certain sections of Nevada, Utah, Idaho, Oregon, and California.

So successful was this first plant expedition that another was organized in 1934, seeking other characters. In a closely grazed goat pasture in northern Turkey the investigators found a single plant that spread over an area of several square feet of soil because it sent up shoots from underground rhizomes. Here was an alfalfa that was different from the usual upright growth of the common types.

The goats had eaten the plant down to such an extent that it was not allowed to produce seed. The live root was extracted and carefully nurtured for the month-long return trip. From vegetative propagations, this plant was tested in several States and proved unadapted to

this country. Again it was the same story of breeding and selection for the desired character. Now in the nurseries of several State experiment stations are new alfalfa types that have the desirable spreading crown with rhizomes, not unlike Bermuda grass. The potential value of this type of legume, adapted to pasture mixtures and hay, cannot be overestimated. But for the sharp eyes of a trained plant explorer, however, we would not today possess such a promising new type of a very old plant.

SUGARCANE

Calamity never came closer to a group of farmers growing a specialized crop than to United States growers of sugarcane back in 1926. Nor has there ever been such a drastic change in the character of a crop as a result of world-wide study and collection of wild and cultivated sugarcanes. The calamity came in the form of a deadly mosaic virus disease. This had reduced sugar production by 1926 to a mere 47,000 tons, not much more than a tenth of previous records. Original research on the virus showed that it was spread from diseased to healthy plants by a small insect. The greatest hope then lay in a search for resistant parent varieties and their development into locally adapted hybrids.

The change in character of sugarcanes in the United States has taken place in the last quarter of a century as a result of the importation of about 1,200 different clones, which are maintained as a living collection at the United States Sugar Plant Field Station, Canal Point, Fla., and at the Canal Zone Experiment Station, Summit, C. Z. This collection is by no means complete, but it represents all known types of sugarcane available for breeding.

Collections have been made systematically, both with respect to species and to areas of natural distribution. Up to the present time about half the known area of natural distribution has been explored for the numerous and widespread forms. Representative collections have been made in Polynesia, Melanesia, except the Solomon Islands, eastern New Guinea, Turkmen S. S. R., Uzbekistan, and eastern and northern Africa. Unexplored areas include most of Malaysia, Indochina, Burma, southern China, India, Afghanistan, and Iran. Many clones have been obtained from these unexplored areas, but a wealth of new material undoubtedly awaits the experienced plant collector.

While the change in character of sugarcane is fairly recent, the story really begins with the discovery of the new hemisphere, for it was Columbus who first brought sugarcane to the new world he discovered. The great expansion of the sugar industry in the French colony of Louisiana did not get under way, however, until the latter part of the eighteenth century. Early explorers of the southwestern Pacific brought back with them new lush-growing sugarcanes with soft stalks of good quality. These were the famed "noble" sugarcanes and replaced the Creole canes derived from the first introductions by Columbus.

With the tropical noble canes, Louisiana's sugarcane industry flourished until the coming of mosaic in the early 1920's. By 1928 Department plant breeders had introduced their first commercial sugarcane with resistance to mosaic—Canal Point 807. Since 1934, 13 more of the C. P. sugarcanes have been introduced, and these represent a care-

ful selection from more than half a million seedlings. These C. P. varieties now occupy more than 75 percent of the acreage in Louisiana.

In addition to mosaic resistance, the changed character of these present-day commercial varieties includes a greater tolerance of cold and greater growth at lower levels of temperature. These characteristics permit uniform success in early fall planting and other advantageous field practices. This is possible because these new varieties are distinctly different botanically and include in their parentage lines of Temperate Zone origin brought in by the plant explorers. Thus the introduction and breeding program not only restored the industry but provided new varieties much better suited to our climatic conditions. From a low of 47,000 tons in 1926, production has jumped to 500,000 tons. And the acreage in sugarcane for this more than tenfold increase is only double that of 1926.

OTHER OUTSTANDING INTRODUCTIONS

Resorting to primitive sources for improvement in these three crops—soybeans, alfalfa, and sugarcane—has not by any means been restricted to them. They are chosen merely as representative examples. Here are a few more that are outstanding:

The great wheat yields of recent years can be traced directly to the introduction and breeding programs of the Department. One of the reasons is that rust epidemics of some years ago no longer take their huge toll. We have rust resistance in all wheat varieties recently introduced into areas where rust is a major hazard. Most of these trace this resistance back to the introduction of Iumillo or Yaroslav emmer varieties, which by themselves were not important but provided the needed rust resistance.

Nearly all the recent oat varieties, which are high yielding because of resistance to crown rust, trace their parentage back to Victoria or Bond, Department introductions from South America and Australia, respectively.

The rice industry of the United States consists almost wholly of varieties introduced by the Department or derived by breeding from such introduced varieties. The well-known Rexoro, Fortuna, Nira, Caloro, Calusa, and Calady were developed from rice introductions.

The million-dollar seed-flax industry of California was made possible by the distribution of two varieties—Punjab and Abyssinian Yellow—which were selected by the Department from introductions received from India and Ethiopia, respectively.

In addition to alfalfa, forage-crop introductions have been many and varied. Their successful establishment has meant much in the heavy expansion of the livestock industry.

Ladino clover came from Italy in 1903 and was first grown widely in the irrigated valleys of the West. It is now becoming firmly established in pasture mixtures in the Northern States. Strawberry clover was introduced from France in 1905 and is filling the need for a legume on saline soils.

In 1921 a half-ounce package of lespedeza seed was introduced from Korea. It is now one of the more important forage crops of the Southeast. Of more recent date is sericea lespedeza, a perennial introduced from China, which has rapidly marched into favor in the same area.

A list of other grasses and legumes introduced in the last 40 years contains the familiar names of Austrian Winter pea, Hungarian vetch, crotalaria, kudzu, Sudan grass, crested wheatgrass—the last two so important in the drier regions—and Centipede, Dallis, Bahia, Napier, Rhodes, and Pangola grasses. Bermuda and carpet grasses became established from earlier introductions.

The Washington Navel orange, introduced from Brazil, and the Meyer lemon, from China, are notable contributions to the citrus industry.

Such specialty crops as avocados, dates, Quetta nectarines, pistachio nuts, tung trees, and blight-resistant Chinese chestnuts owe their existence in this country to a planned introduction program of the Department.

This is only a partial list of foreign crops that are now growing successfully in this country. Nor has plant exploration and introduction been confined to crops of foreign origin. Many crops native to this hemisphere have received literal "shots in the arm" from the importation of new germ plasm.

A typical example is the tomato. Commercial varieties some years ago were attacked by a new disease, fusarium wilt. The Department obtained from Peru a wild species no larger than a cherry but possessing the needed resistance to wilt. This resistance has been incorporated by hybridization with commercial varieties and released to growers in the form of the new variety Pan America.

Potatoes are still another example. Some of the best parent lines now being used in the National Potato Breeding Program, because of their resistance to scab and other diseases, came from Germany before the beginning of World War II.

FUTURE EXPLORATION OPPORTUNITIES

In taking stock now of the last 50 years in plant exploration and introduction, an evaluation of the achievements points to even greater opportunities. In building a program of plant introduction, the pioneer scientists in this work have done monumental work in devising means of collecting plant specimens, keeping them alive in transit, and propagating and testing them for possible use. The ecologist, the cytologist, the pathologist, and the geneticist have learned to identify and bring out the best in the never-ending quest for superior germ plasm in which the primitive source is often the mother lode.

On the record of what has happened, the Congress, in passing the Research and Marketing Act of 1946, saw fit to include the following specific language: "* * * research to encourage the discovery, introduction, and breeding of new and useful agricultural crops, plants, and animals, both foreign and native, particularly for those crops and plants which may be adapted to utilization in chemical and manufacturing industries. * * *"

This is the challenge today. This statement of objectives demands a revitalized program of plant exploration and introduction. Meeting with representatives of the State agricultural experiment stations, this Bureau is now engaged in the planning of a truly complete national program with four major objectives. These are:

1. The introduction of new plants that can be used directly in supplying primary materials for chemical or manufacturing industries.
2. The introduction of plants possessing special characteristics, including disease and insect resistance, cold or drought tolerance, and other qualities that can be utilized in breeding programs to improve economic plants for agricultural or industrial use.
3. The evaluation, cataloging, and preservation of introduced plants, so that strains of potential value in future breeding programs or for future industrial development will be continuously available.
4. The evaluation, cataloging, and preservation of native plant materials or plants presently available in the United States that have not been adequately tested for industrial or agricultural use.

For the most part these objectives represent a reemphasis on a program already in existence. But the national program envisions the establishment of a planned program of action and support of the States that will bring into sharp focus its valuable and yet untouched possibilities.

It contemplates the planned exploration in foreign countries for new crop plants based on needs as determined by research workers concerned with crop improvement and industrial utilization of crop products. Unfortunately, few such explorations could be made in the last 10 years.

It calls for the development of a more complete physical plant in the form of regional introduction gardens, where the new plant materials can be tested more rigorously for adaptation in the various ecological areas of the United States. From these gardens, information would be distributed annually to State agricultural experiment stations in the area so that plant breeders will know what materials are available and can utilize them promptly.

To insure necessary inspection and quarantine of new introductions and thereby prevent the introduction of new plant diseases and pests, and to provide one recognized center for the maintenance of inventory records and a central information point, the Division of Plant Exploration and Introduction, of this Bureau, will continue to perform these necessary primary functions. To coordinate these activities there will be a National Committee for New Crops and a Regional Committee for New Crops for each of the ecological areas.

Thus, we look to the future with a confidence based on the possession of a sound program, in which the ultimate aim is to give to American farmers and to American industry all that the wide world offers.

U. S. GOVERNMENT PRINTING OFFICE 1948—O–777952